Fermilab High Intensity Proton Accelerator: Project-X

Project X is a multi-MW proton facility proposed for construction at Fermilab. Project X is based on an H^- linear accelerator (linac) employing superconducting rf technology. Project X will provide long-term opportunities in both the energy and intensity frontiers. The technology development is closely aligned with the technologies that required for the International Linear Collider (ILC), and this development preserves Fermilab as a possible host, or major contributor, to such a future facility. The development of multi-MW capabilities also could provide a basis for a future Muon Collider or Neutrino Factory. In parallel Project X provides great flexibility on the intensity frontier, offering the opportunity for a long-term world-leading program in neutrino physics and other beyond-the-standard-model phenomena. Finally, the technology developed for Project X opens opportunities beyond traditional Elementary Particle Physics applications, for example in cold-neutron physics and accelerator driven (subcritical) systems (ADS) for energy generation and/or transmutation of waste.

The initial design criteria for a multi-MW proton source have been established based on the requirements outlined in the P5 report [3]:

- A neutrino beam for long baseline neutrino oscillation experiments based on a proton source capable of delivering at least 2 MW of beam power at any energy over the range 60-120 GeV;
- High intensity 8 GeV protons supporting muon and kaon precision experiments, simultaneous with the neutrino program; and
- A path toward a muon source for a possible future Neutrino Factory or Muon Collider. This requires that the initial facility retain the potential for upgrading to 2-4 MW at 8 GeV.

Two configurations that meet these requirements have been developed. The first is based on an 8 GeV pulsed linac, and the second on a 3 GeV continuous wave (CW) linac to be followed by either an 8 GeV rapid cycling synchrotron (RCS) or a 3-8 GeV pulsed Linac. Both configurations utilize the existing Recycler and Main Injector rings for the accumulation of beam and acceleration to 60-120 GeV.

The goal of the Project X Research, Design, and Development (RD&D) Plan is to complete a fully developed technical description, construction schedule, and cost estimate by 2013. This effort is currently underway and is being undertaken by a multi-institutional U.S. collaboration composed of Argonne National Laboratory, Brookhaven National Laboratory, Cornell University, Fermilab, Lawrence Berkeley National Laboratory, Michigan State University, Oak Ridge National Laboratory, Thomas

Jefferson National Accelerator Facility, SLAC National Accelerator Laboratory, and the Americas Regional Team of the ILC Global Design Effort. Fermilab proposed to build Project-X as a US national project with international partners. Indian laboratories through the Addendum MOU III are the first international collaborators on Project-X. Assuming successful completion of the RD&D phase, physical construction could start in 2015, with construction completed over a roughly five year construction period.

The present configuration of the Project-X complex is shown in Figure 1. The 3 GeV CW linac section is the focus of this collaboration discussion. The beam line labeled Nuclear could be made available for experiments that focus on Nuclear Energy R&D.

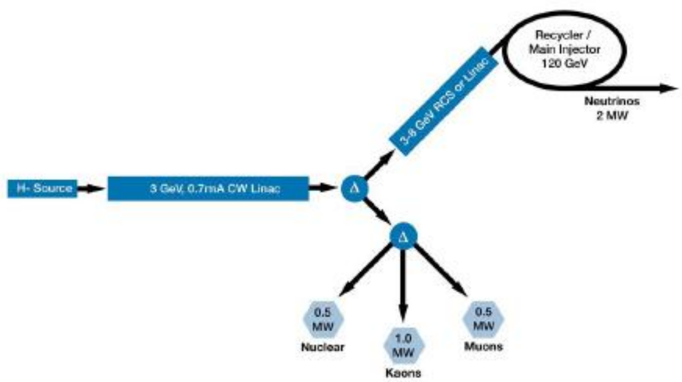

Figure 1: Project-X Configuration

Technology deployment for the SRF linac is shown in Figure 2. This configuration is not fully optimized and hence only represents current concept. We propose to focus the Project-X R&D on this configuration of CW Linac.

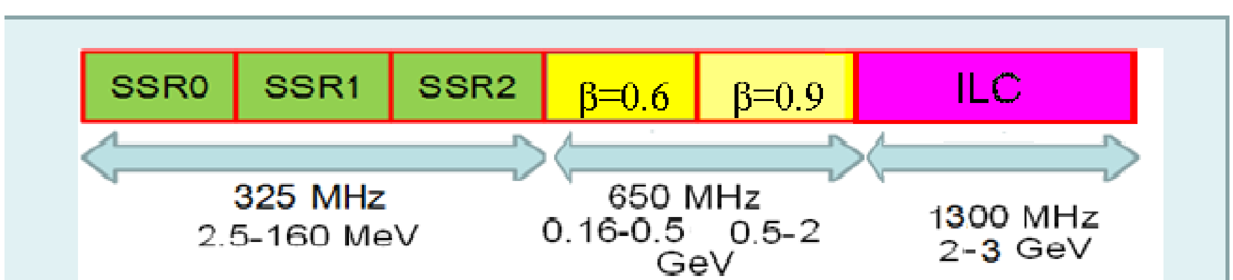

Figure 2. Initial configuration of the cw linac in Project-X. .

A 10 mA dc ion source and 162.5 MHz RFQ are followed by a MEBT operating at 2.5 MeV. Development of the flexible chopper described above, which resides in the MEBT, will be one of the most challenging goals of the RD&D phase of the program. The upstream acceleration section is based on superconducting spoke resonator cavities designed to various betas. This section operates at 325 MHz and is envisioned as extending up to roughly 160 MeV. The following section is based on two similar designs of 650 MHz elliptical cavities with beta=0.6 and beta = 0.9 respectively.

Section	Freq	Energy MeV	Number of cavity/magnet/CM	Type of
Re-bunching RT Cavity (β_G=0.11)	325	2.5	4	Pill-box cavity Triplet
SSR0 (β_G=0.11)	325	2.5-10	18 /18/1 26/26/ 1	Single spoke cavity, Solenoid
SSR1 (β_G=0.22)	325	10-32	18 / 18/ 2	Single spoke cavity, Solenoid
SSR2 (β_G=0.4)	325	32-160	44 / 24 / 4	Single spoke cavity, Solenoid
LB 650 (β_G=0.61)	650	160-520	42 / 21 / 7	5 cell cavity, doublet
HB 650 (β_G=0.9)	650	520-2000	96 / 12 / 12	5 cell cavity, doublet
ILC 1.3	1300	2000-3000	64 / 8 / 8	9-cell cavity, quad

Table 1: Break points and number of components

The 650 MHz section will accelerate the beam to 2 GeV. The 650 MHz section, as compared to previous beta = 0.8, 1300 MHz section, is introduced to improve the overall design including higher acceleration and capture efficiency. The linac is completed with beta=1.0 cryomodules using a modified ILC cavity operating at 1.3 GHz. This section takes the energy to 3.0 GeV. The elliptical cavity technology is very similar to that required for the ILC, although the power couplers and rf distribution system will be different. Prototypes of both the lowest beta single spoke resonator and the beta=1.0 elliptical cavities have been built and successfully tested. Table 1 shows the break points and number of components in the Project-X 3 GeV linac.